

Patent Application  
Attorney Docket No.: 57983.000037  
Client Reference No.: 13527ROUS01U

**EXHIBIT A**

# Invention Disclosure Submission Reply

Disc No:	13527RO
Title:	Domain-constrained optical route flooding system for optical UNI and optical VPN services

## — Inventors —

Serial No.	Name	Work Info	Home Info
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## — Attachments —

<End of Attachments>

Is this submission for a patent application?	yes	Is this submission for a patent application?	no
Name of Applicant	STEVE LACHOWSKI		
Name of Invention	OTHER (CORP)		
Is this invention a continuation of a previous invention?	yes		
Is this invention a continuation of a previous invention?	yes		
Is this invention a continuation of a previous invention?	yes		

Abstract/Summary/Highlights	
Keywords/Classification	
Products/Inventions/Innovation	
Does this invention relate to a specific product or service? <input type="checkbox"/> no	
Is this invention related to a specific product or service? <input type="checkbox"/> no	
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**Technical Information**

**Brief Description of the Invention**

Optical network is designed to provide end-to-end light paths between user CPEs. With wavelength routing, Wavelength signaling and network resource partitioning capability, the future optical network will provide Optical VPN (Virtual Private Network) services for customers. The optical connectivity services are provided through Optical UNI (User Network Interface). Over Optical UNI, a set of functions is defined to support end-to-end light path services. These functions include to set up (tear down) the paths, to change the bandwidth dynamically against an existing path, to inquire user group information, and to get some optical layer topological information. To achieve about objective, IETF and OIF have defined some initial proposals for Optical routing, Optical signaling and Optical UNI. Three optical interworking service models have been proposed in IETF and OIF: Overlay model, Peer-to-peer model and Augment model. In Overlay model, the optical domain is separated from the other service layer domain such as IP routing domain. In this model, IP layer is a client layer of Optical layer while Optical layer is a server layer to provide light path services for IP through Optical UNI. The peer-to-peer model treats IP and optical evenly. In this model, IP routers treat optical switches as another type of "router", thus IP layer and Optical layer can exchange routing information seamlessly. The third model is an integrated model (Augmented model). In this model, the IP layer act as peers of the optical layer network, such that a single routing protocol instance runs over both IP and optical domain. Unlike peer-to-peer model in where the routing domain is a "flat" space, the Augmented model restricts the routing information of optical domain only at the boundary between IP and optical switch. In the other word, only the optical-attached router will exchange the routing information with Optical switch, not further. Which model is better for IP/Optical interworking is still a debatable topic in IETF, OIF and ITU. The fundamental issue here is how to partitioning overall network resources and who is supposed to manage what portion of these resources. This disclosure has defined a unified mechanism which can support all the three service models at the same time. We have introduced "Optical Link User Group Identification (OLUGI)" for each optical link to partitioning routing domain for various optical user groups. Coordinated with wavelength routing protocol, this OLUGI is used to restrict the optical route flooding into optical network user domain based on pre-assigned flooding policy. This mechanism not only provides optical service providers a great flexibility to support various optical service model and traffic engineering, but also sets up a basis for optical VPN services in which the customer could buy a portion of optical bandwidth and manage this resource themselves.

**Problems Solved by the Invention**

IETF and OIF have defined three optical service models for IP/Optical interworking: Overlay model, Peer-to-peer model and Augmented model. Each model has its own advantage and applies to a specific service scenario. This invention defines Optical Link User Group for each model, and defines the optical route flooding policy for each user group. This flooding policy restricts the route-flooding domain for each optical user group. Wavelength routing protocol is extended to propagate this information to various user groups. This method provides a policy-based routing such that the optical layer only floods route information to a "trustable domain". This "trustable domain" is defined by Service Level Agreement between optical service provide and customers. The optical network user can use this method to discover the users in the same group, and to check the status of the peer user. This method could also support Optical VPN services, in which case the customer can buy and manage a portion of optical bandwidth, through a distributed manner.

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While IETF and OIF are still debating which service model is better for IP/Optical interworking, we see that a consolidate model to support all three models will be most beneficiary for both optical service provider and optical network users. For example, the service provider MCI can support overlay model to un-trustable users by providing end-to-end light path services. At the same time, MCI optical transport group can support Peer-to-Peer model or Augmented model for MCI-UUNet group. When UUNet group hooks up their Terabit routers to optical core, by learning optical layer topology, the IP domain can conduct traffic engineering by dynamically allocate/release optical bandwidth, and even conduct IP layer protection more efficiently and reliably. This invention is the first proposal to support such consolidate optical service model.

~~Specific elements of this invention are described below.~~

The Service Model information, User Status information and Optical Link User Group Identification information will be defined for Wavelength routing protocol as follows:

Service model TLV: This TLV is a 32-bit integer component, the value is 0 ~ 30: default model, no service1: Overlay model. In this model, no optical route information is flooded into user domain2: Augmented model. In this model, part of optical route information is allowed to flood into user domain3: Peer-to-peer model. In this model, all optical route information will be flooded into user domainUser Status TLV: This TLV is a 32-bit integer component, the value is 0~3.0: Out of service - This user cannot be connected1: Idle - This user is ready to accept connection request2: Busy - This user cannot receive any more connection3: Testing - This user is being tested. Cannot accept any connection at this momentOptical Link User Group Identification TLV: This TLV is defined in OSPF resource LSA as Administrative group. We define some new semantic for this TLV. It is a 32-bit integer.255.255.255.255: Broadcast group. Any optical topology information would be flooded over this link0.0.0.0: Default for disabled group. No optical LSA allowed over this linkOther: Same as OSPF administrative group. It is defined for specific user group. Optical route flooding restriction for various user group: When an optical switch receives an Optical Link State Advertisement (OLSA), it will check the link type for each link to decide if this OLSA should be flooded over that link:Link Type

Flooding restriction255.255.255.255 Flood LSA over this link0.0.0.0 Block LSA over this linkOther value Flood LSA only if the administrative group value is matched. For traditional OSPF LSA, based on link ID of LSA, the optical switch will compare the link type of LSA and the link type of all out-going link, then decide over which link this LSA should be flooded.

~~Commercial value of this invention to Nortel and Nortel's competitors are described below.~~

This invention will provide Nortel an approach to support various service models for IP/Optical interworking. Based on the domain-constrained flooding policy, this method provides a unified optical route flooding mechanism for Optical UNI service, it also provide an effective approach for Optical VPN services. Potentially, this approach could be merged into the on-going standard activity for IP/Optical interworking in IETF and OIF.



# **NORTEL NETWORKS**

## **Optical Metro Ethernet Network (O-MEN) :**

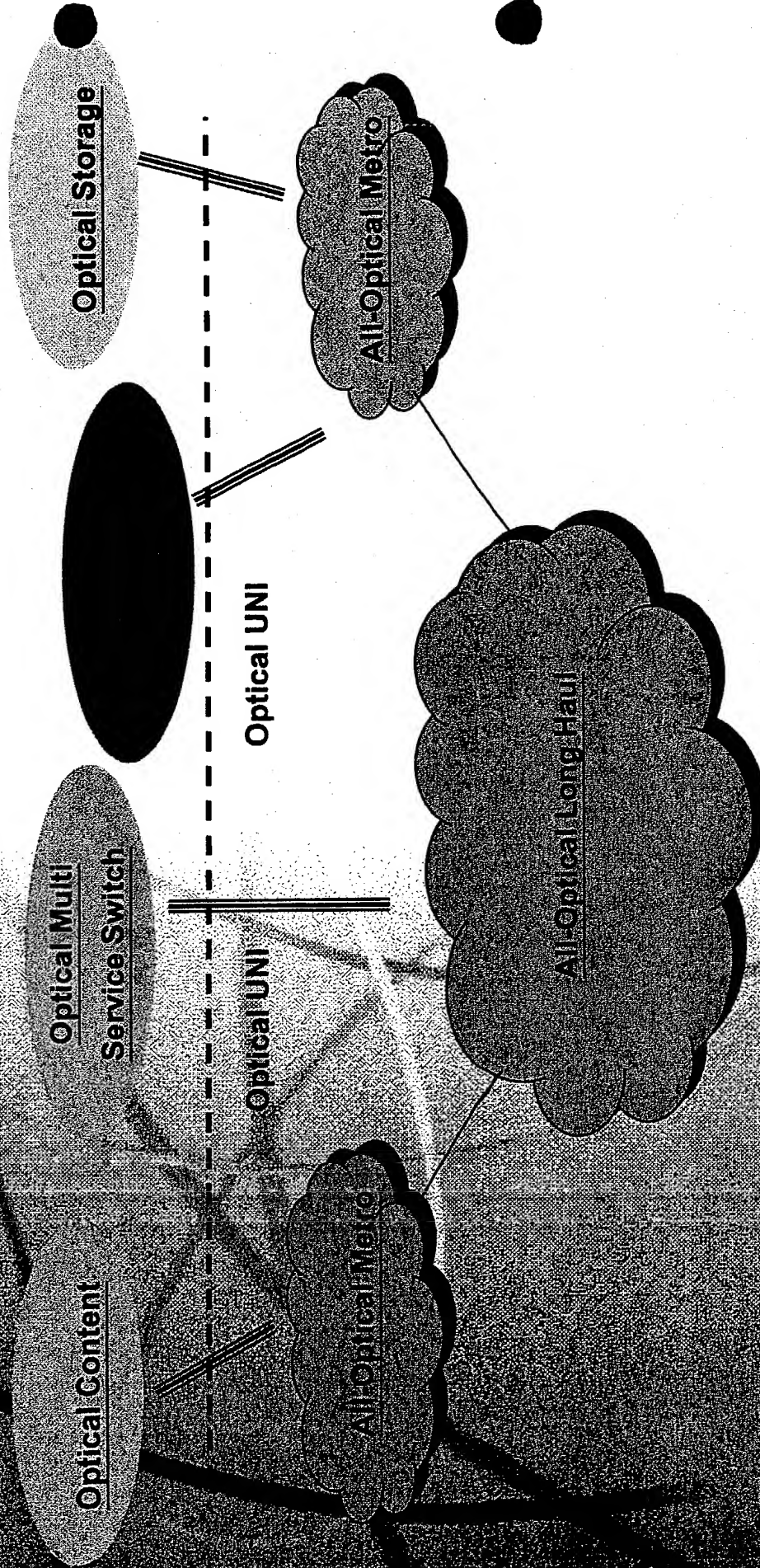
### ***Service and Control***

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# Global Opticalization





# Optical user, services and service modes

## Optical User

- Trusted User
- UN-trusted user

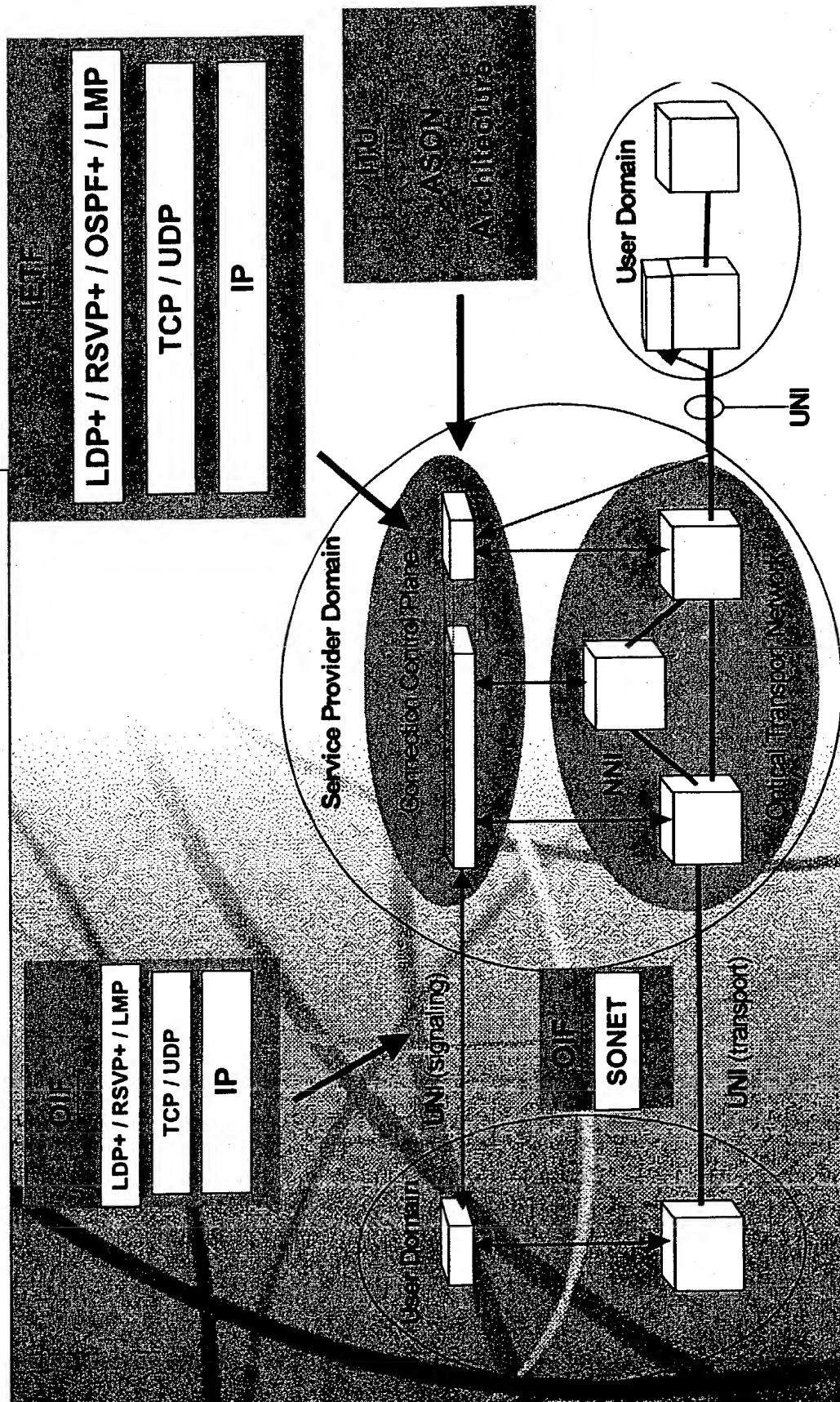
## Optical service

- O-UNI management
- Optical dial tone and protection
- End-system discovery and service discovery
- Third party signaling
- Leased line
- Optical VPN
- Bandwidth trading

## Optical service mode

- Overlay
- Peer-to-peer
- Augmented

# O-UNI / O-NNI Reference Model





# Standard: OIF, IETF and ITU

## OIF

- "O-UNI 1.0 Proposal" -- OIF2000.125.2
- "Carrier Optical Services Framework and Associated Requirement for O-UNI"
  - OIF2000.155.1
- "LDP Extension for UNI 1.0" -- OIF2000.140.1

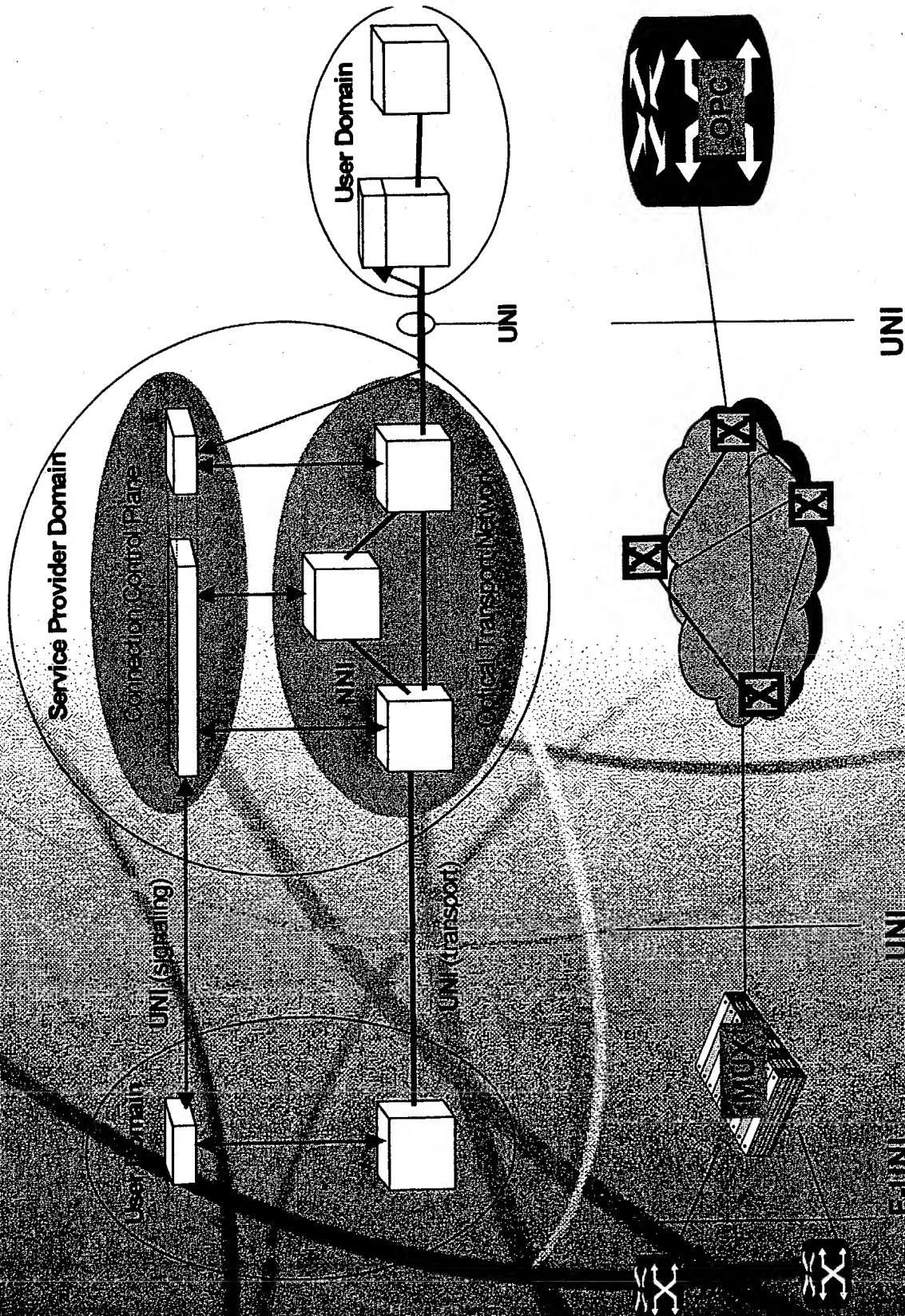
## IETF

- "Generalized MPLS -- Signaling Functional Description"
  - draft-ietf-mpls-generalized-signaling-00.txt
- "Extension to OSPF/IS-IS for Optical Routing"
  - draft-ietf-lambda-te-routing-00.txt
- "Link Management Protocol" -- draft-lang-mpls-lmp-00.txt

## ITU

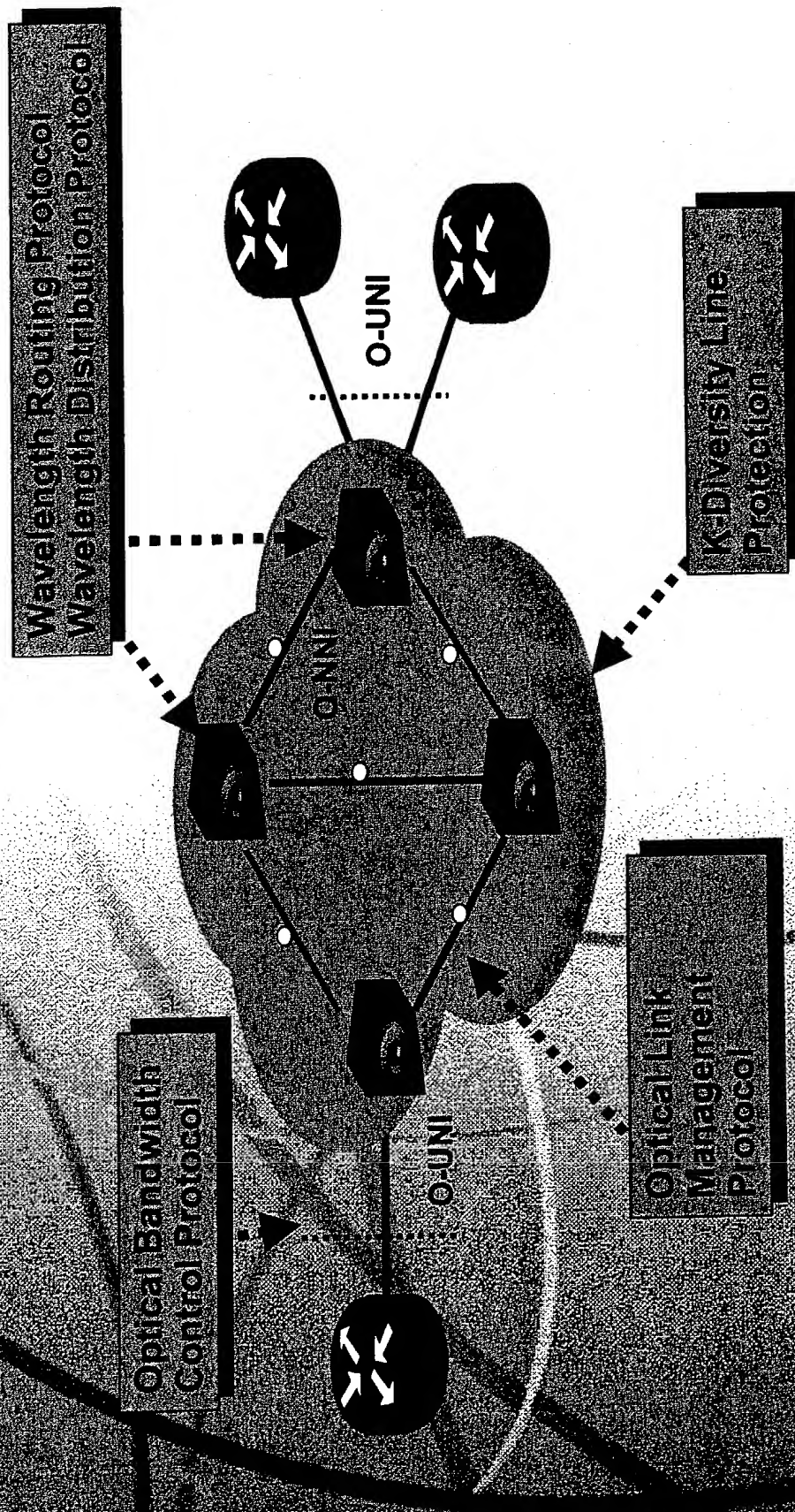
- "Network Node Interface for the Optical Transport Network"
  - ITU-T Draft New Recommendation G.709
- "Architecture of Optical Transport Networks", ITU Recommendation G.872
- "Architecture for Automatic Switched Optical Network (ASON)"
  - ITU Rec. G.ason,

# O-UNI Reference Model



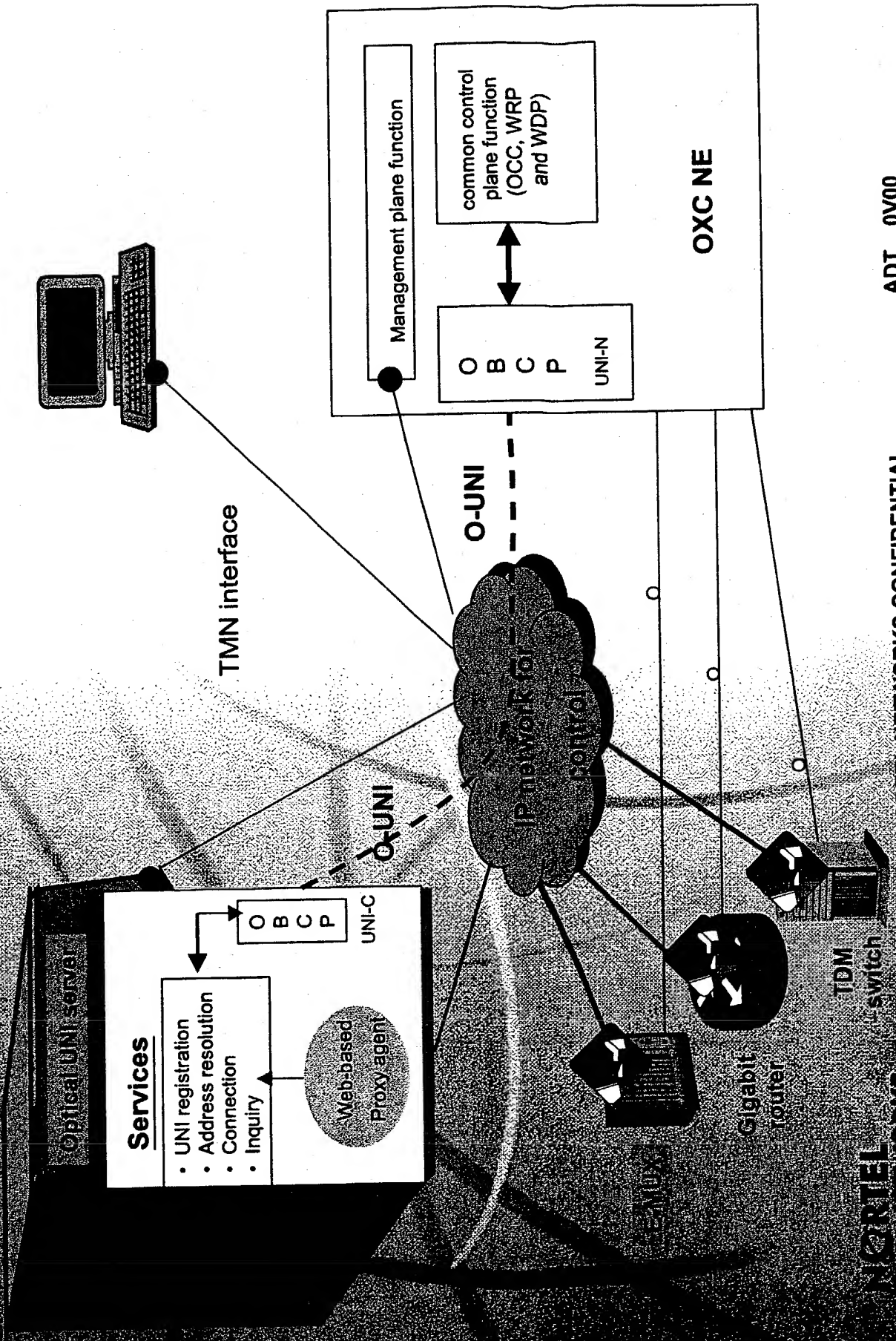


# Optical Intelligent Protocols



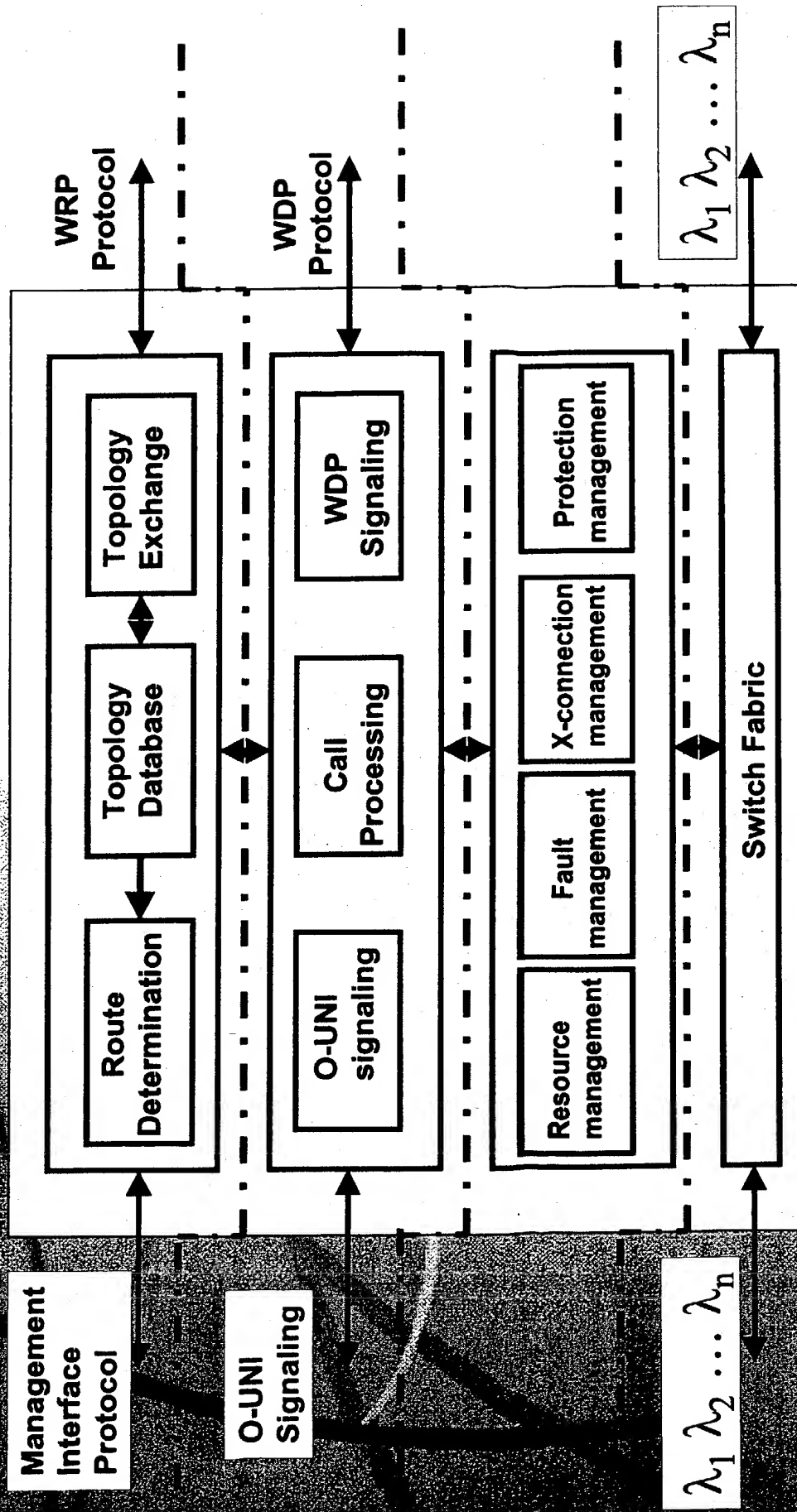


# O-UNI client-server distributed architecture

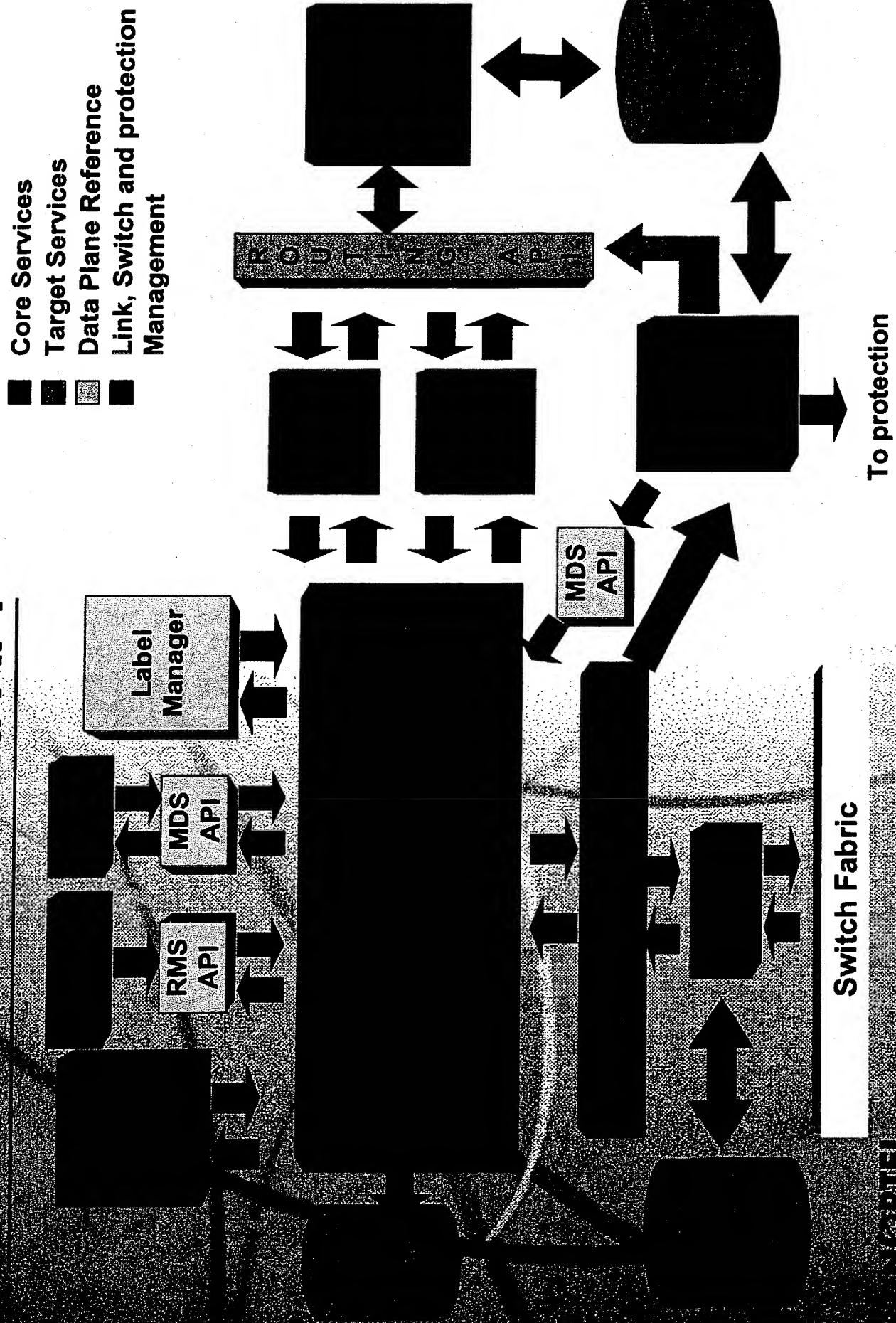


# WRP & WDP

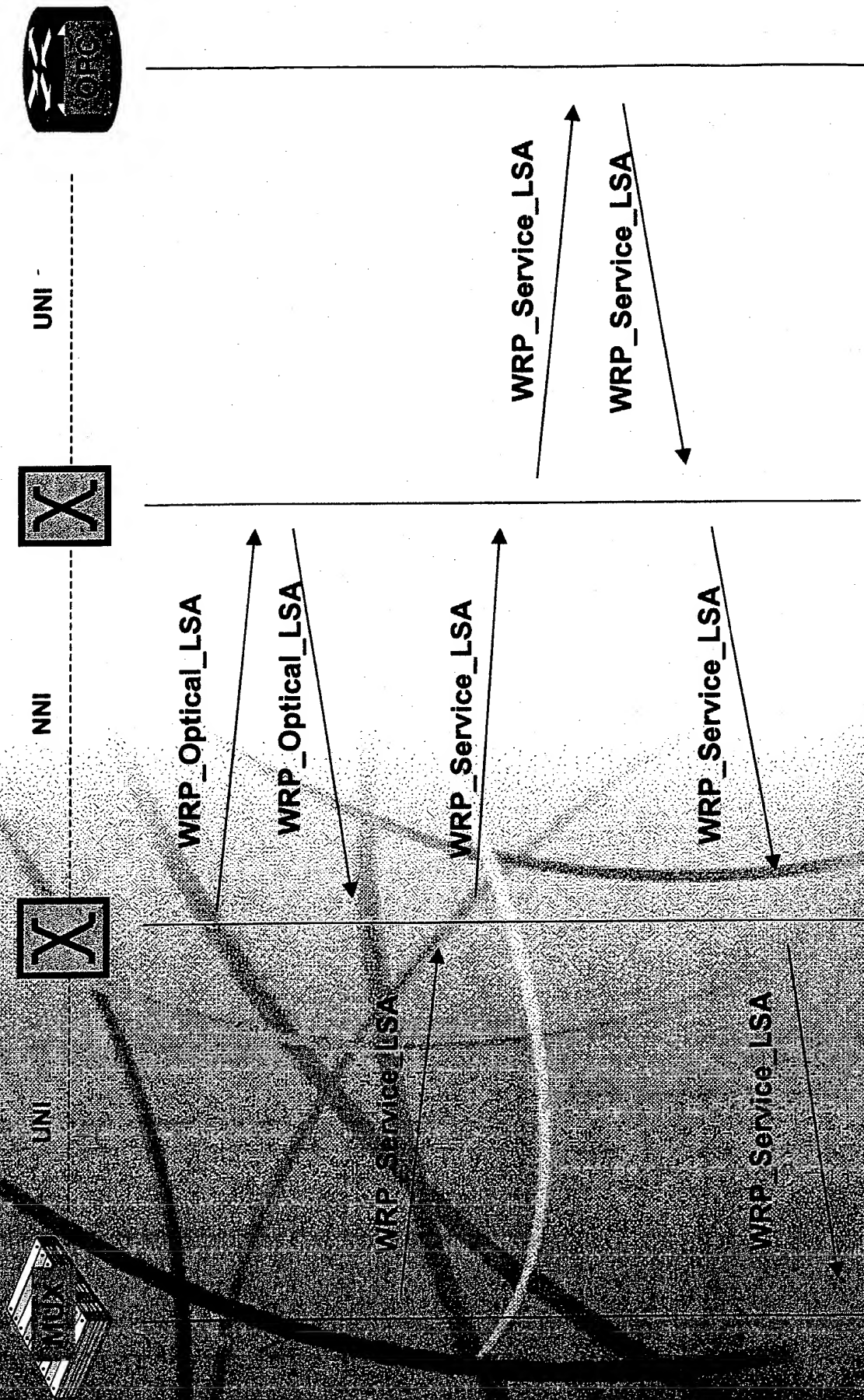
## System Control Architecture Reference Model for an Optical Switch



# Control Blocks and API



# Control Messaging Flow Chart -- routing

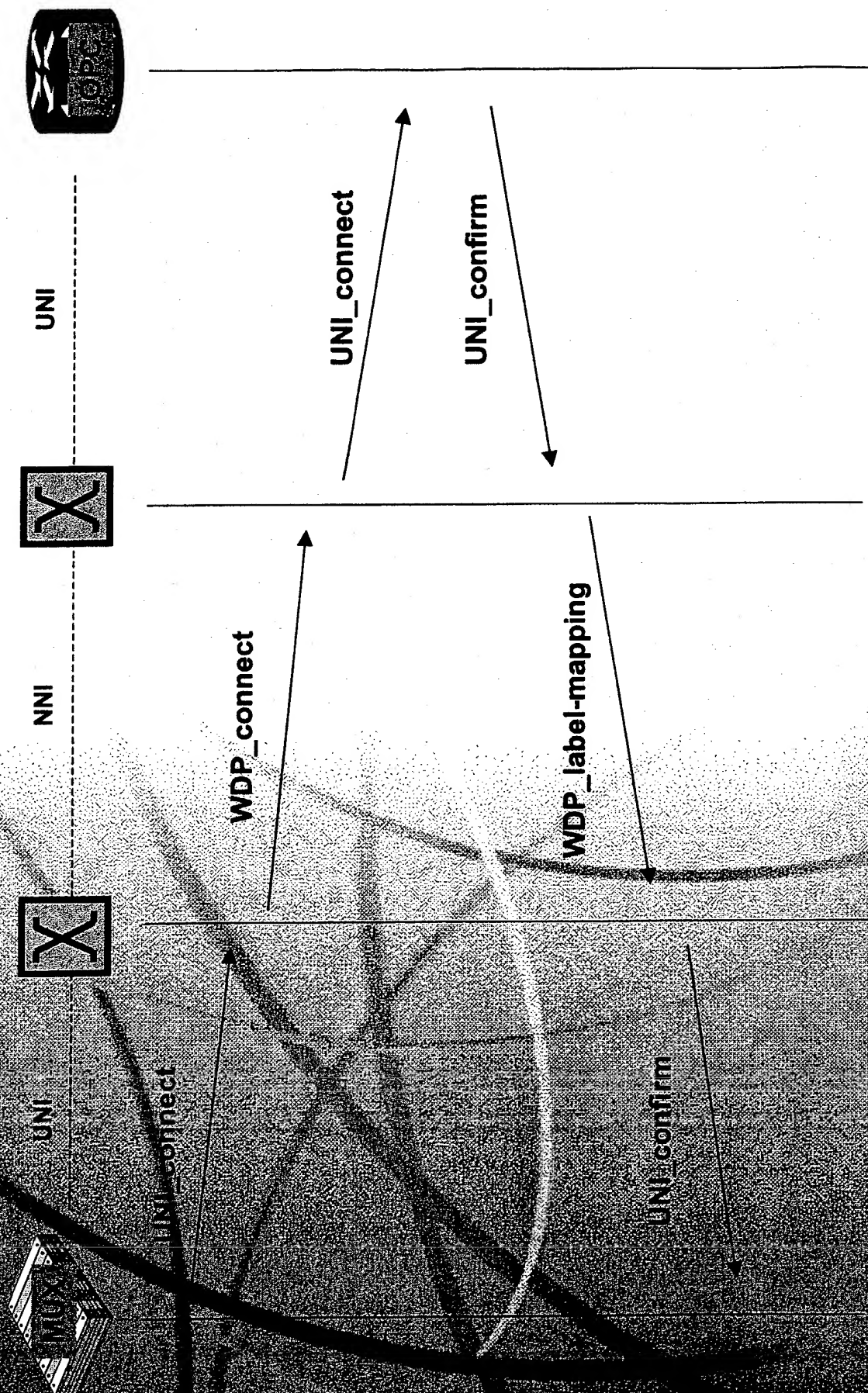


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# Control Messaging Flow Chart -- signaling



# WRP & WDP

## WRP Requirement

### ◆ WRP

- Optical topology discovery and inventory of physical resource
- Available/reserved resource advertisement
- Optical bandwidth grouping at various channel granularity
- O-UNI interworking & control integration
- Channel/link prioritization advertisement
- New path selection/optimization algorithm to support traffic engineering and constrain-based routing
- All interfaces (ports) are IP-addressable
- Integrated protection/restoration

# WRP & WDP

## WDP Requirement

### ◆ WDP

- Classified label for connection type and bandwidth
- End-to-end signaling to setup, tear-down and modify optical paths
- Optical traffic/interface compatibility check
- Bandwidth assignment for optical switches with/without wavelength conversion, at various granularities with any combination
- Path priority assignment for protection and traffic engineering



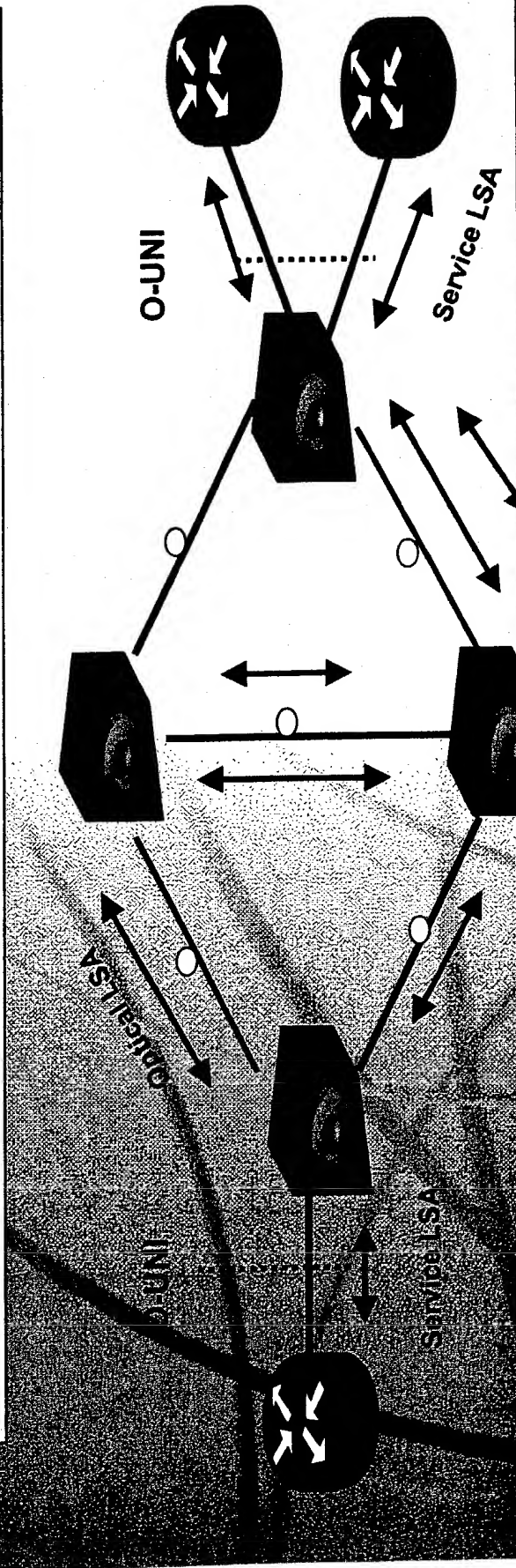
# Optical Bandwidth Control Protocol

## OBCP Requirement

### ◆OBCP

- O-UNI registration/de-registration
- Connection request/release/bandwidth change
- Service status inquiry
- Service singling and protection
- Neighbor discovery and service discovery
- Optical augment routing
- Third-party signaling and scheduling services
- O-VPN services
- Service policy enforcement
- Service billing

# Optical LSA and Service LSA Propagation



## WRP& WDP

- 1.NNI is configured for each optical link
- 2.WRP floods Optical LSA and exchange topology for routing database
- 7.WDP consults from WRP to get a constraint-based path
- 8.WDP issues connection request with the check of the optical UNI interface type user group ID, and available bandwidth.
- 9.The request is confirmed or rejected.

## O-UNI & OBCP

- 3.O-UNI is configured for each service access link
- 4.OBCP floods Service LSA
- 5.Optical switches check flooding domain to decide broadcast or block the propagation to other OBCP server
- 6.OBCP accepts service request from O-UNI proxy, conduct address resolution and forward the request to WDP
- 10.The request is confirmed or rejected.

# Optical Link Management Protocol

## OLMP Requirement

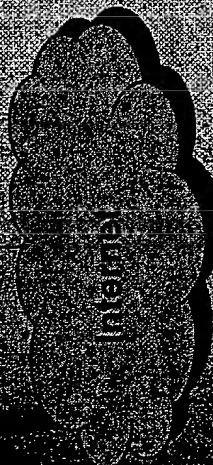
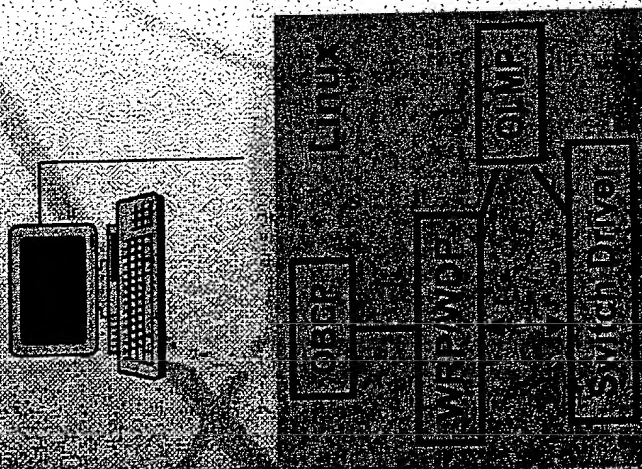
### ◆OLMP

- ↳ Neighbor discovery
- ↳ Link type, wavelength scope identification and negotiation
- ↳ Bundling link
- ↳ Control channel management and protection
- ↳ Component link verification
- ↳ Fault detection and fault isolation



NWUnet

System control  
Configuration

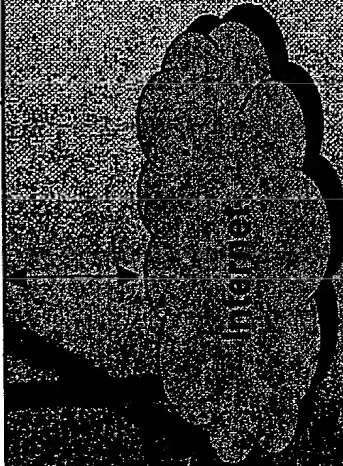
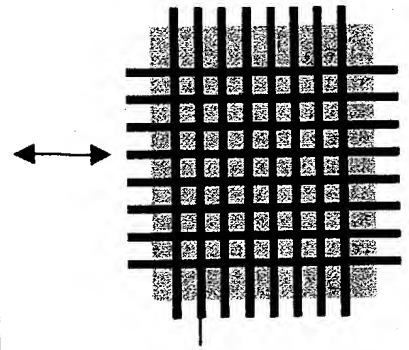
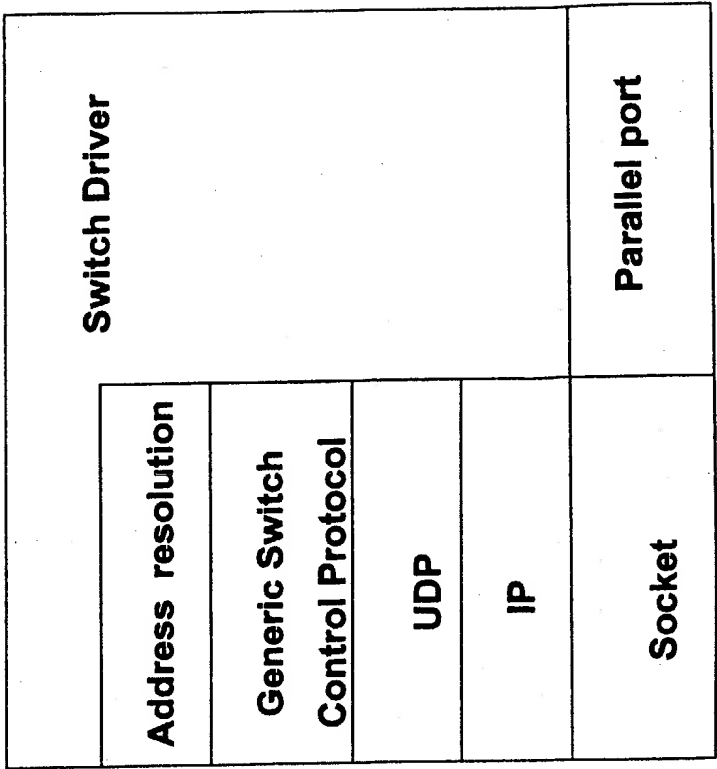
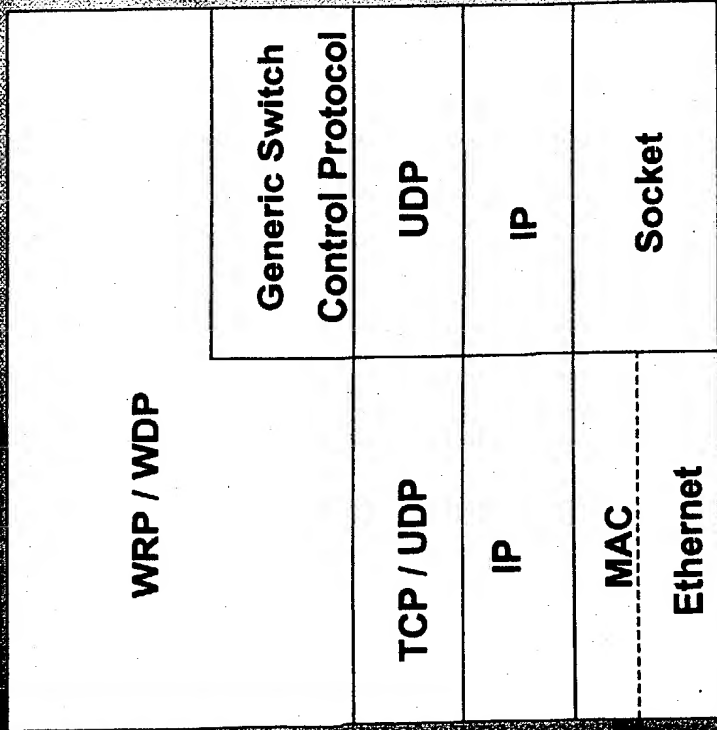


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# NWUnet: Communication Stack



# NWUmet: Switch Control message flow chart

WIRP/WDR

Switch Driver

Connect (Connection\_ID, S\_port, S\_channel, S\_sub-channel,  
D\_port, D\_channel, D\_sub\_channel)

Connect\_Resp(Connection\_ID, status, reason)

Disconnect (Connection\_ID, S\_port, S\_channel, S\_sub-channel,  
D\_port, D\_channel, D\_sub\_channel)

Disconnect\_Resp(Connection\_ID, status, reason)

Inquire\_status(Connection\_ID)

Inquire\_status\_Resp(Connection\_ID, status)

Alarm(Port, channel, sub\_channel, type)

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## **Summary**

### **Services**

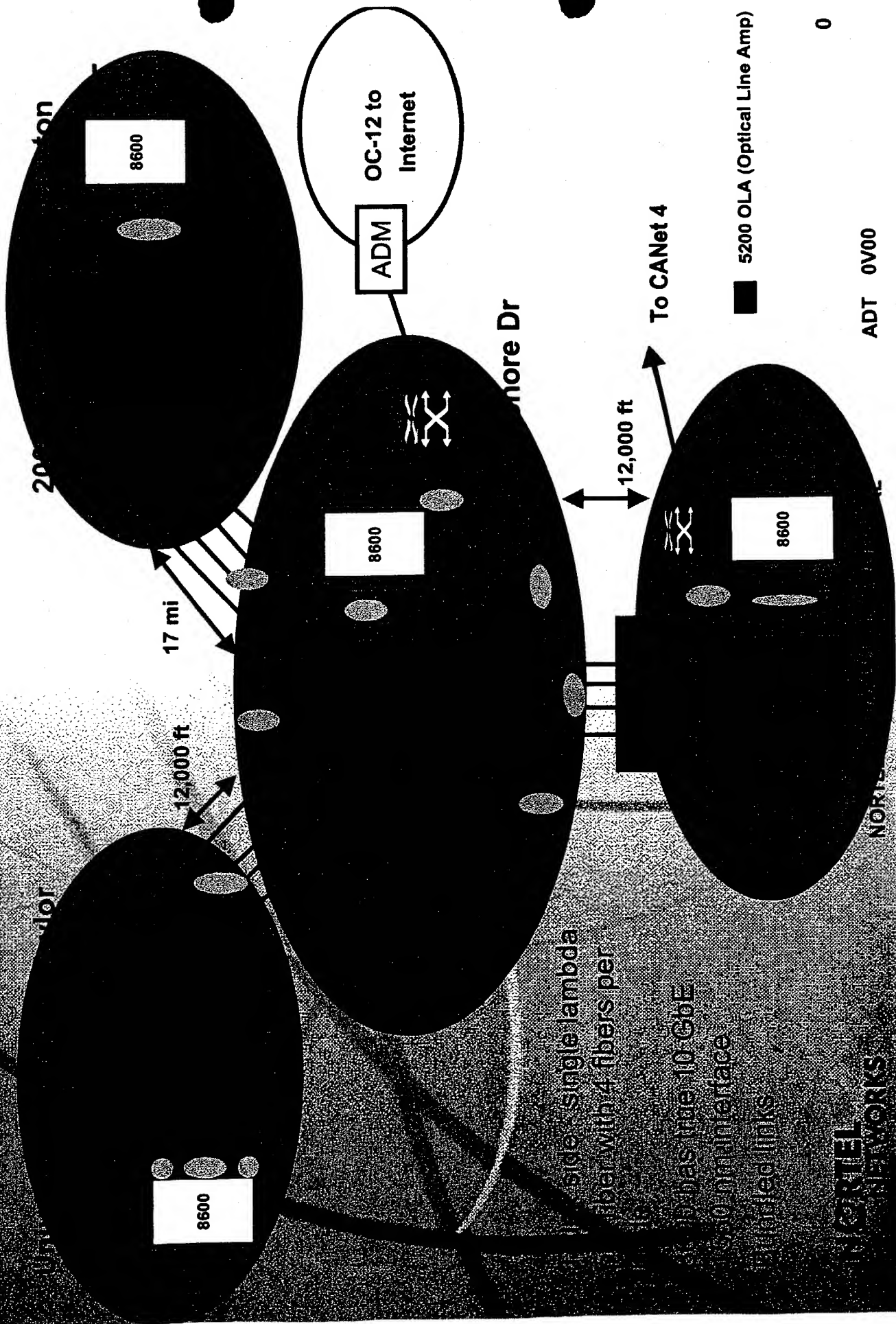
- O-UNI signaling & routing
- Optical Dial tone & protection
- Service automatic discovery
- O-VPN

### **Control**

- Out-band, out-fiber, IP-based transport for signaling
- WRP/WDP for routing & signaling
- OBCP for O-UNI services
- OLMP for link management & fault isolation

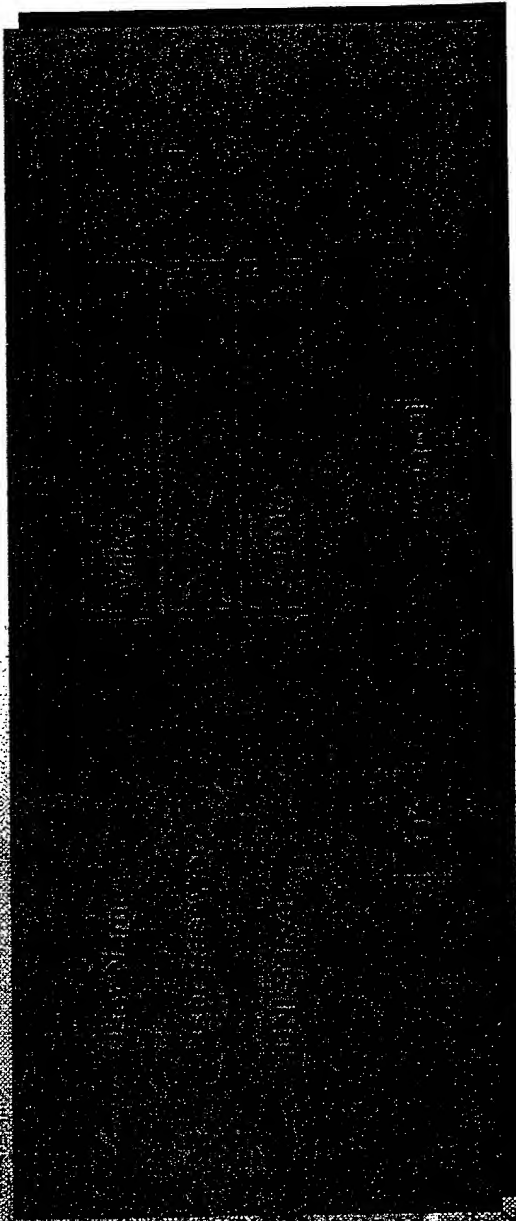


# Network Configuration phase I



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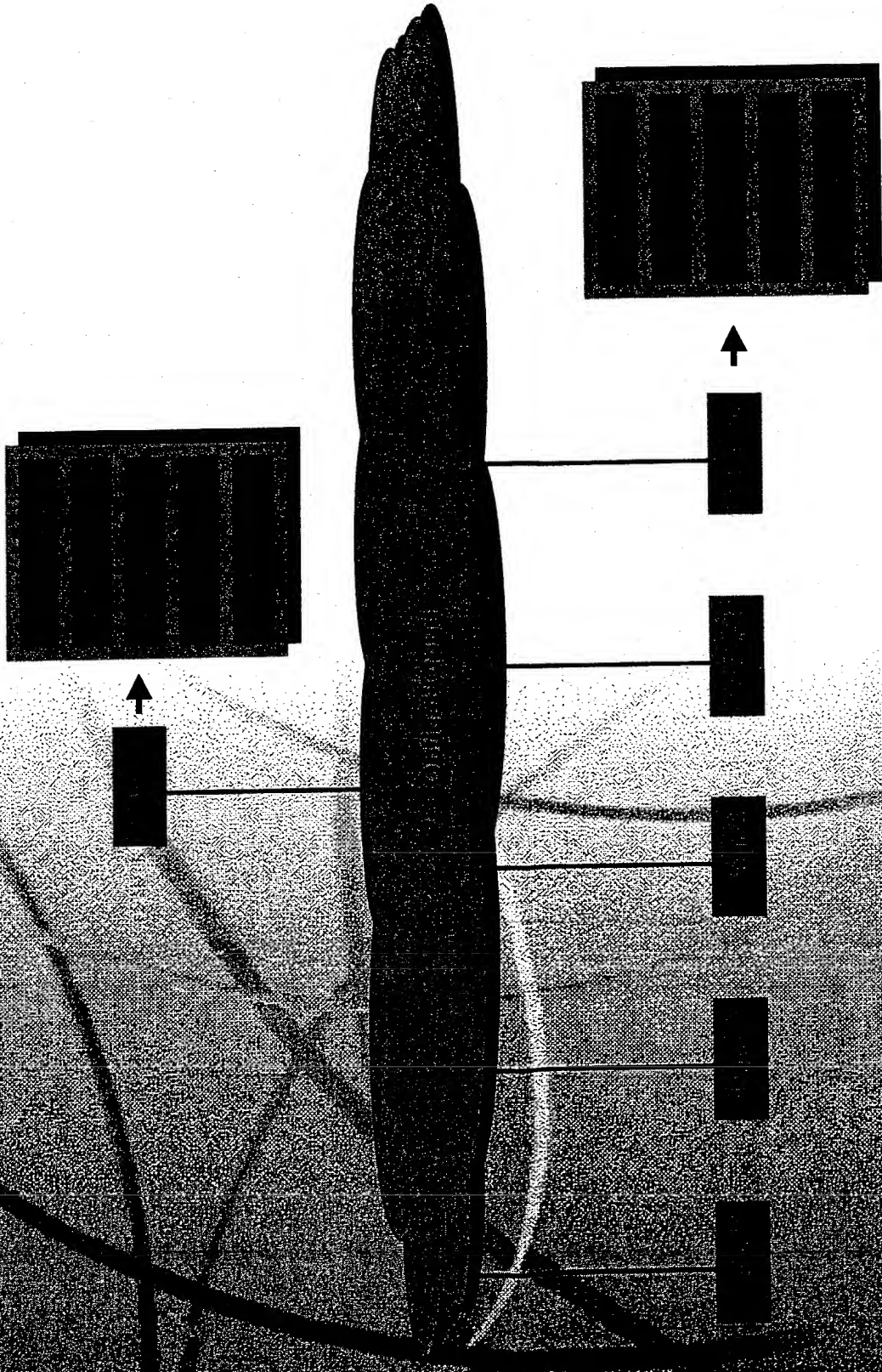
UNII Login GUI



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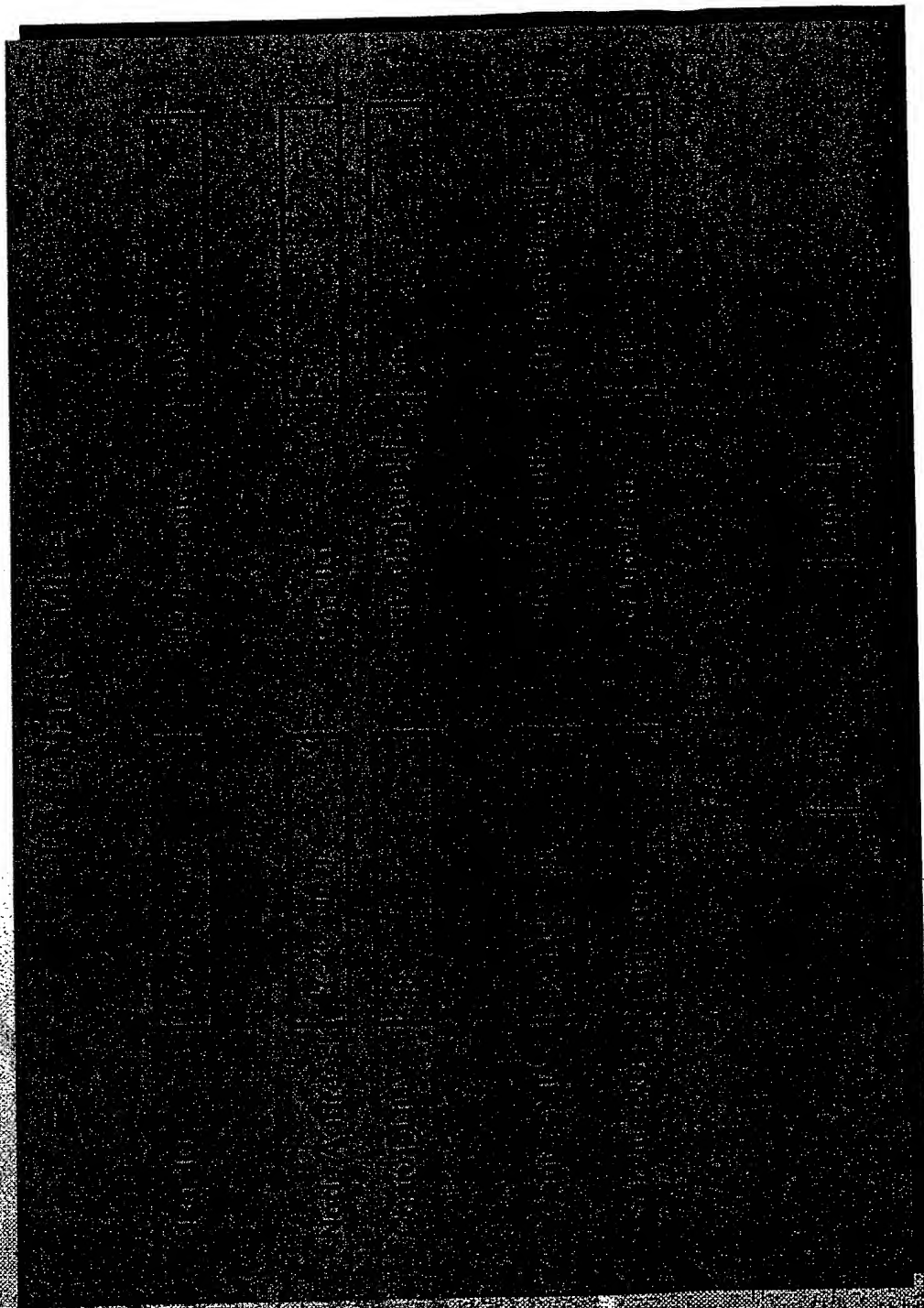
GUI Main GUI



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# GUI Property GUI

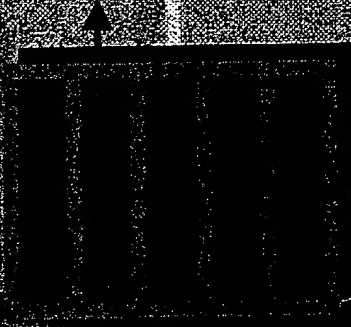
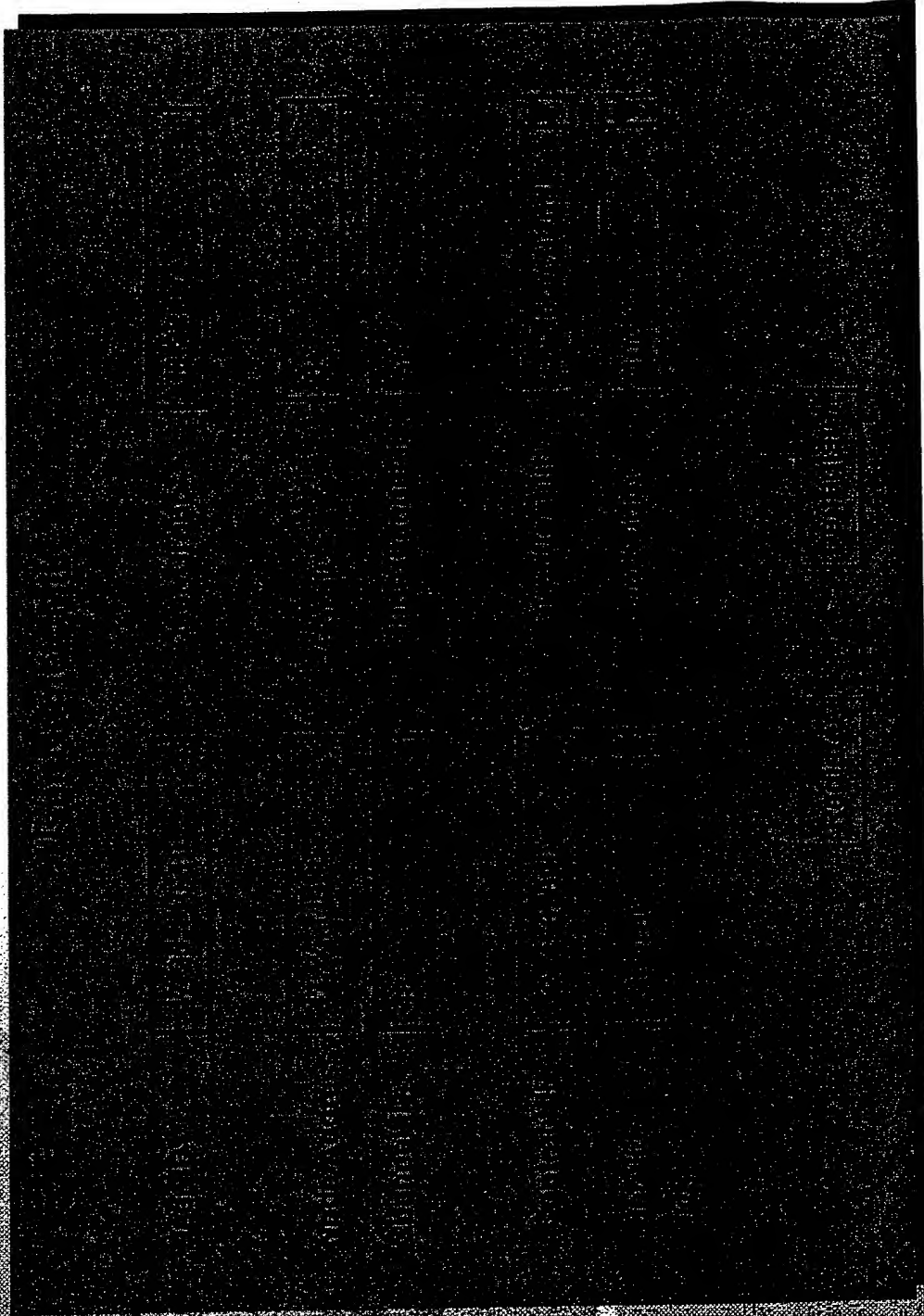


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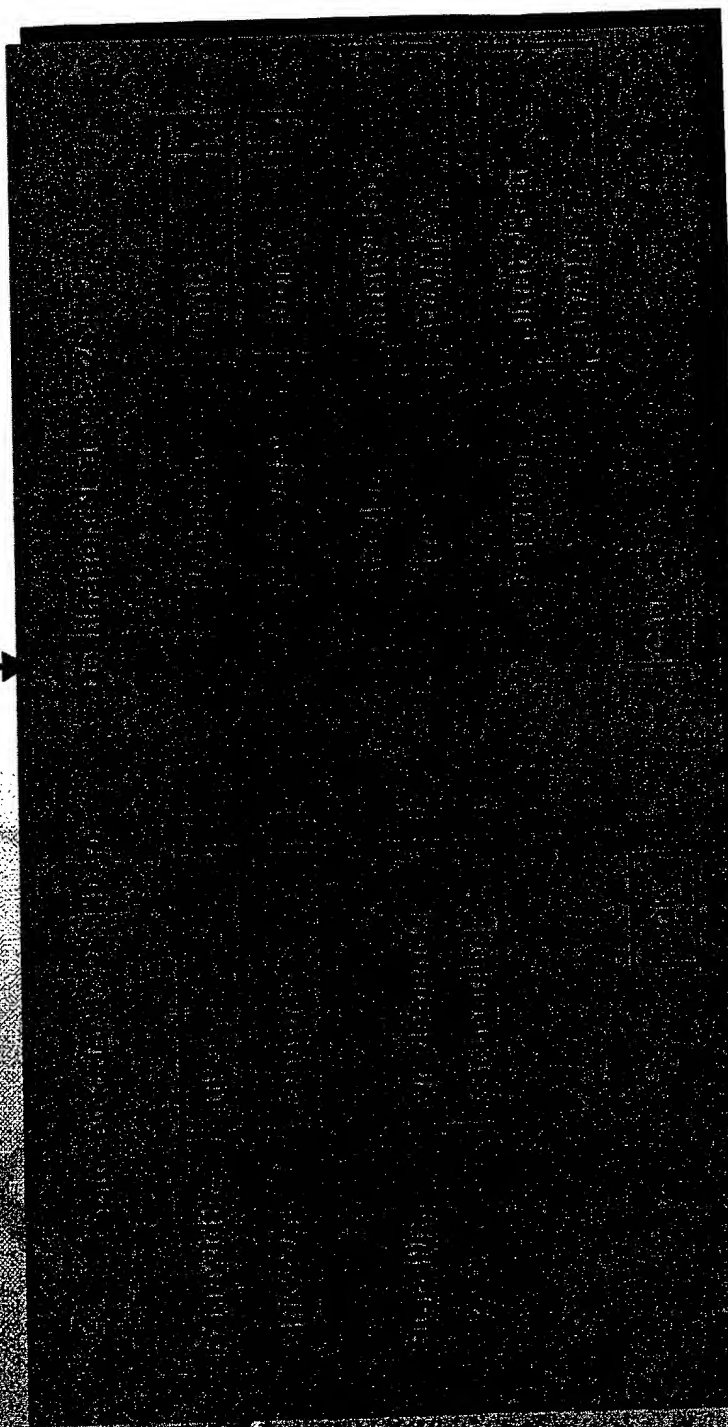
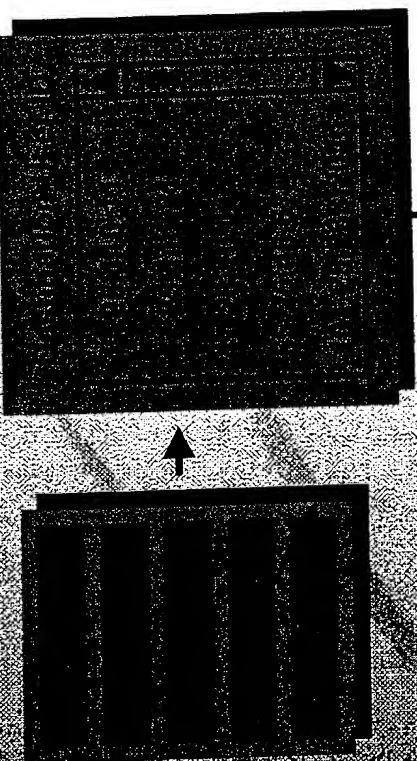
# Register/De-register GUI



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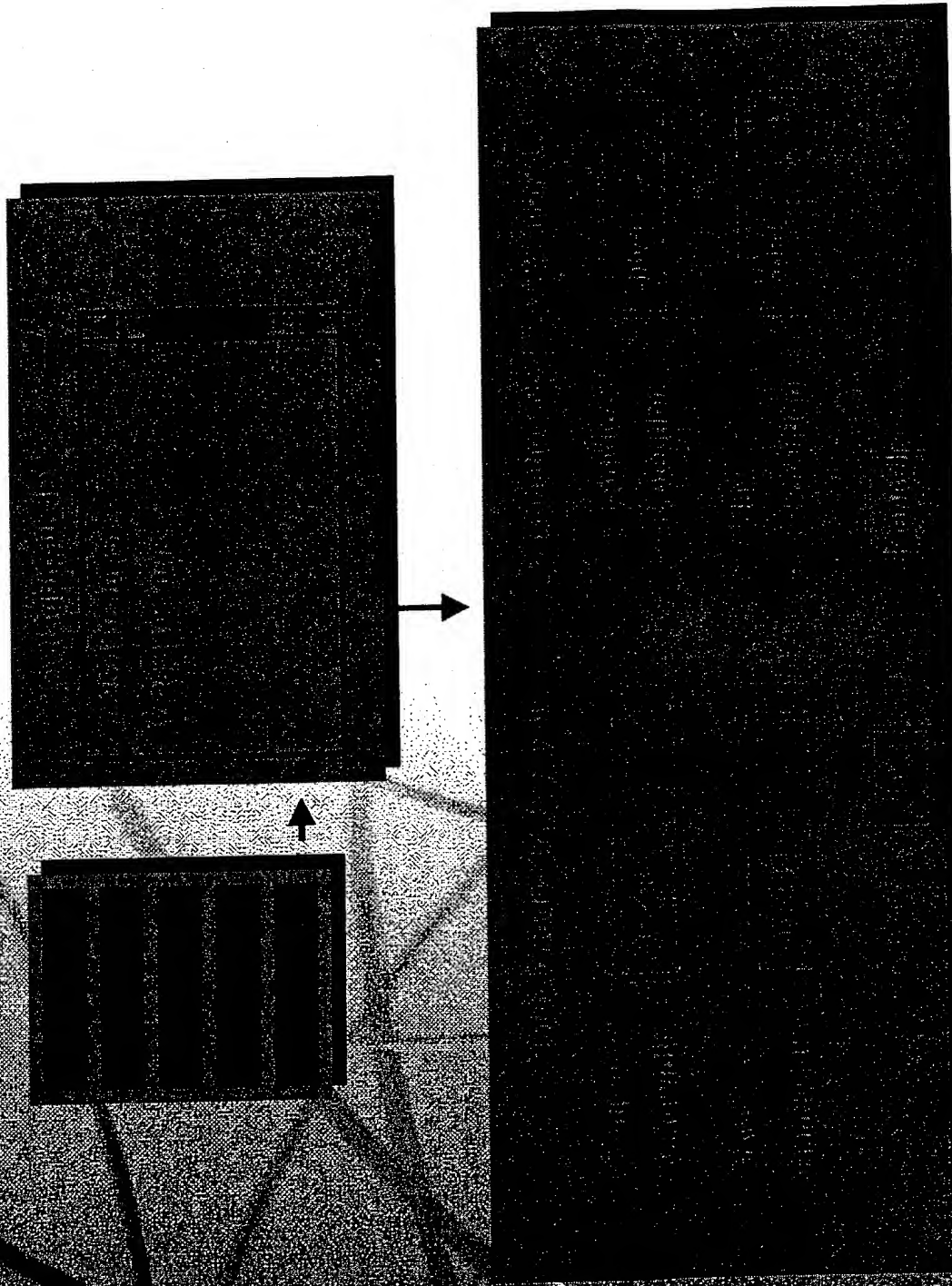
# UNI Connect/Disconnect GUI



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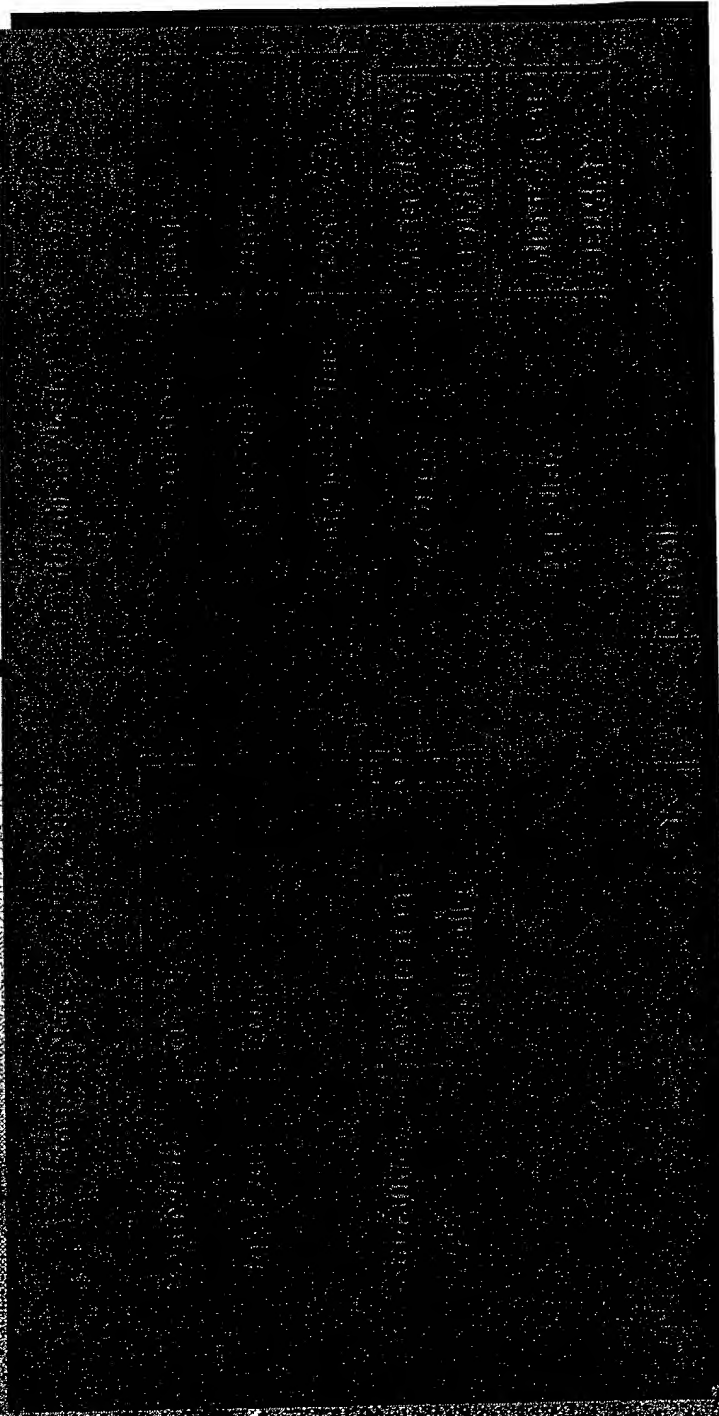
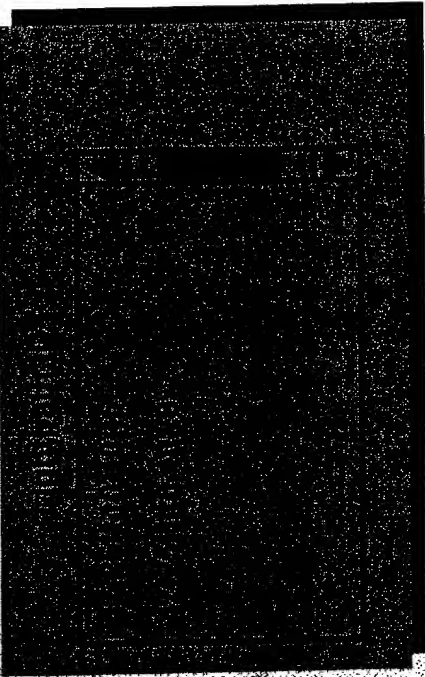
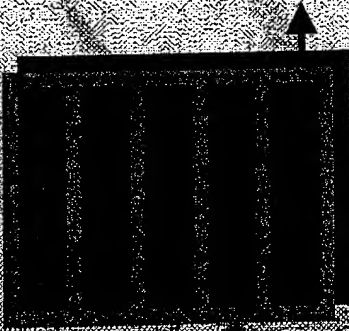
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# Modify Lightpath GUI





# Quirey Lightpath GUI



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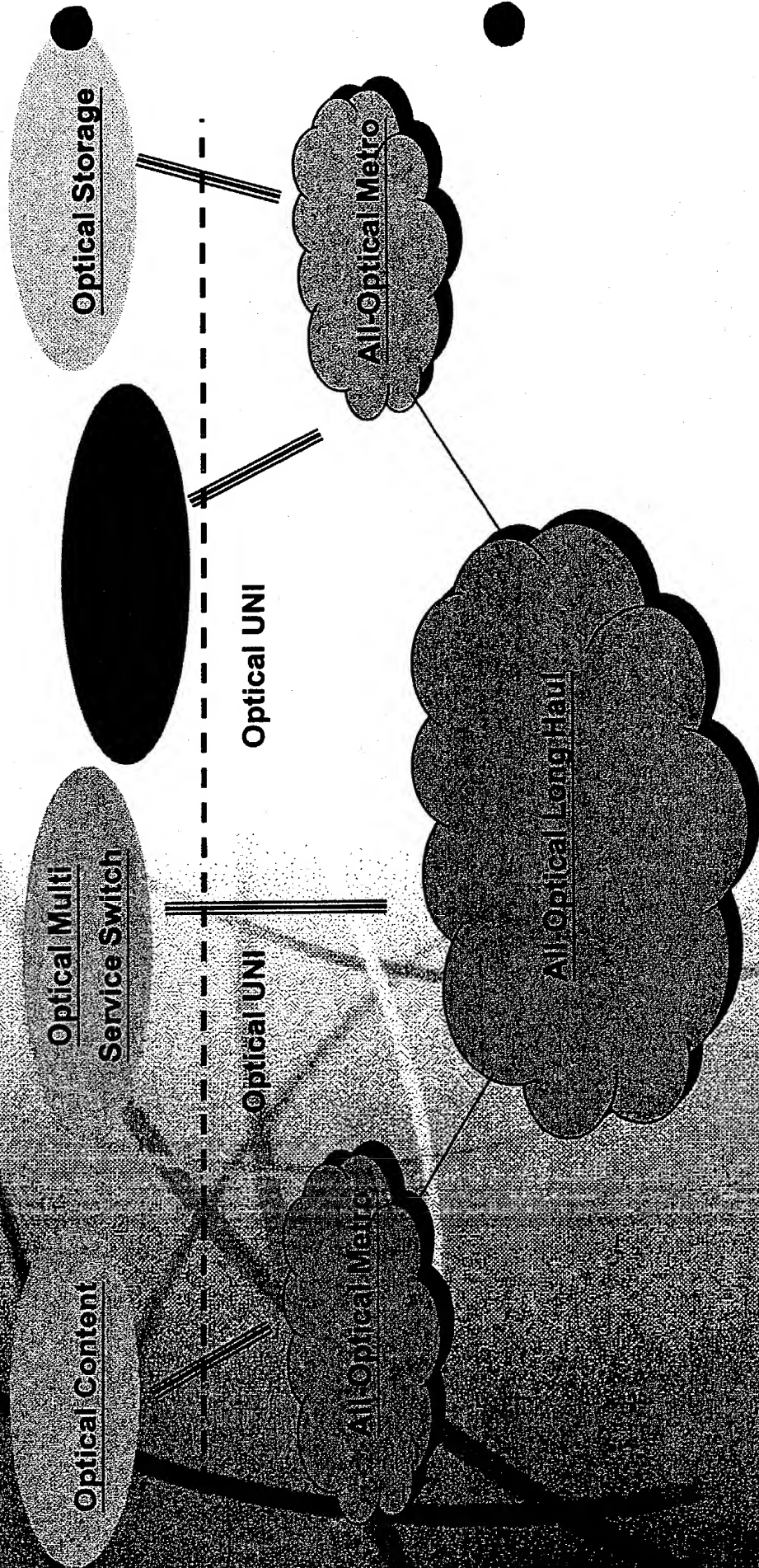
## Optical Augment Routing: User-constrained Optical route flooding system for hybrid optical service modes

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# Global Opticalization





## **Major points of this invention**

- Routing over UNI to support IP/Optical interworking
- Service link LSA for UNI
- New link semantic for constrained optical route flooding

**Hybrid optical service mode for O-VPN**



# Optical user, services and service modes

## Optical User

- Trusted User
- UN-trusted user

## Optical service

- Optical dial tone and protection
- End-system discovery
- Third party signaling
- Leased line
- Optical VPN
- Bandwidth trading

## Optical service mode

- Overlay
- Peer-to-peer
- Augmented

# Who manage what optical resources

## Overlay model

- For UN-trusted user
- IP routing is independent from optical networks
- User signal bandwidth & protection via O-UNI signaling protocol
- Optical service providers own all optical resource (No optical routes disclosed to user)

## Peer-to-peer model

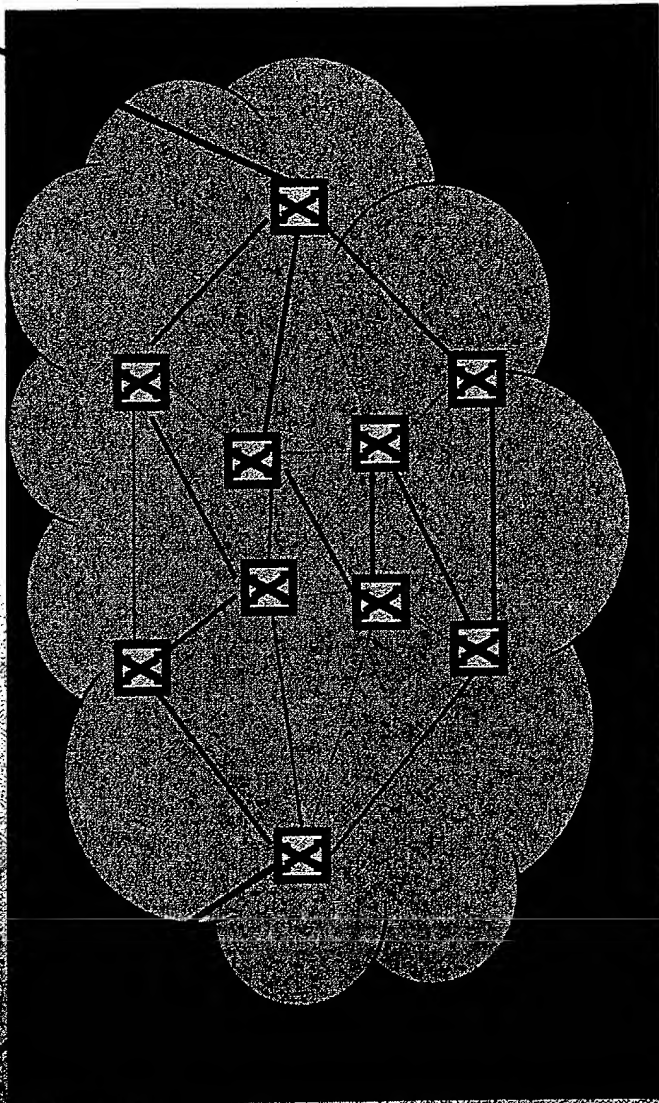
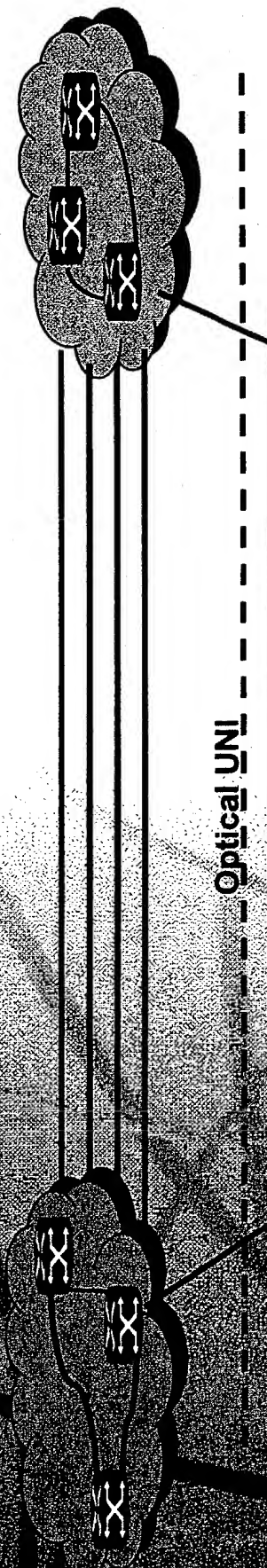
- For trusted user
- User signal bandwidth & protection via extended IP protocol (NNI protocol)
- User own all / partial optical resource via unified routing protocol
- Optical routes flooded into IP domain as typical IP routes (links)

## Augmented model

- For trusted user
- Separate routing protocol instances in IP and optical domain; But
- IP routing shares optical topology information at the optical edge
- Optical routes flooded into IP domain at the edge devices only.



# Overlay Model



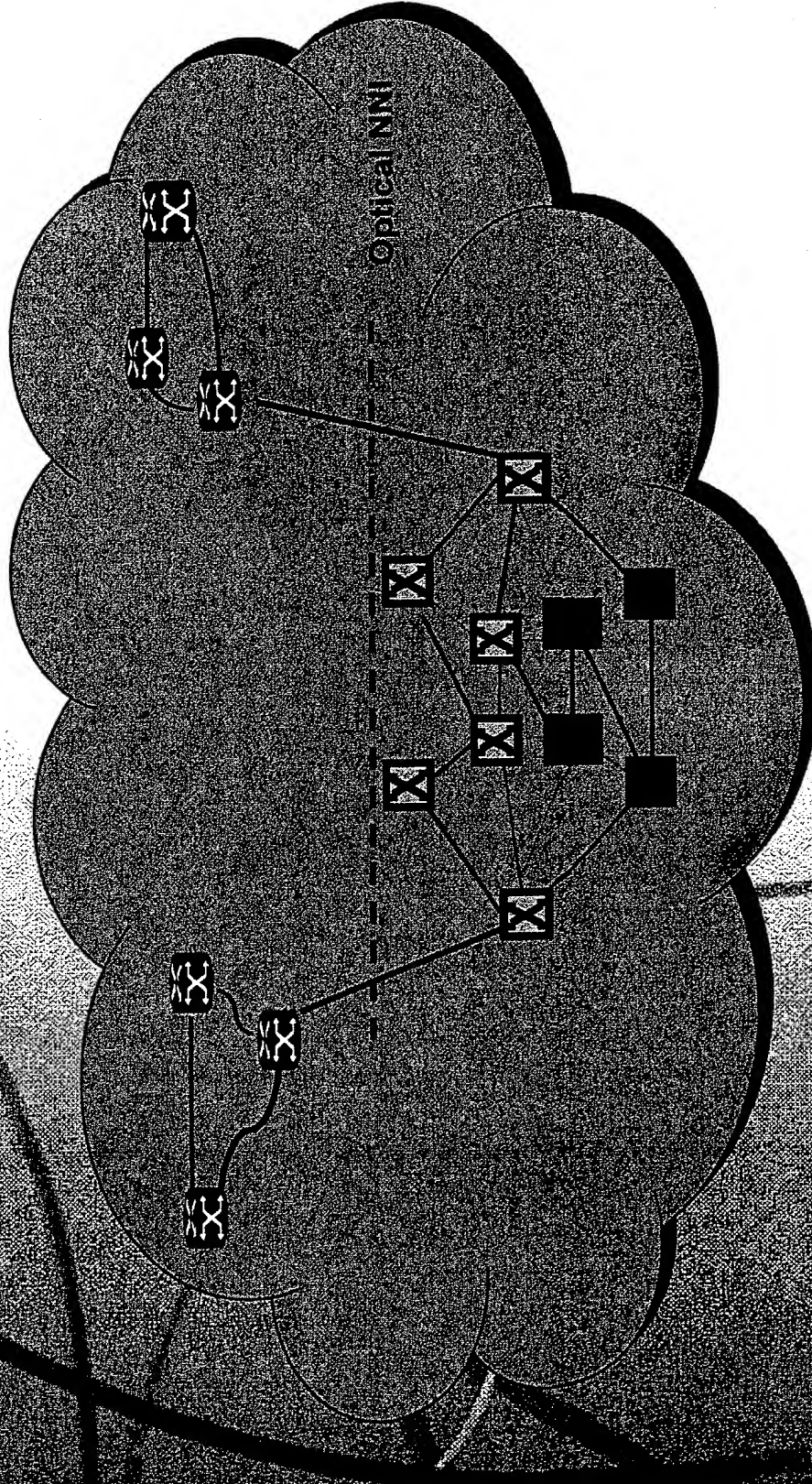
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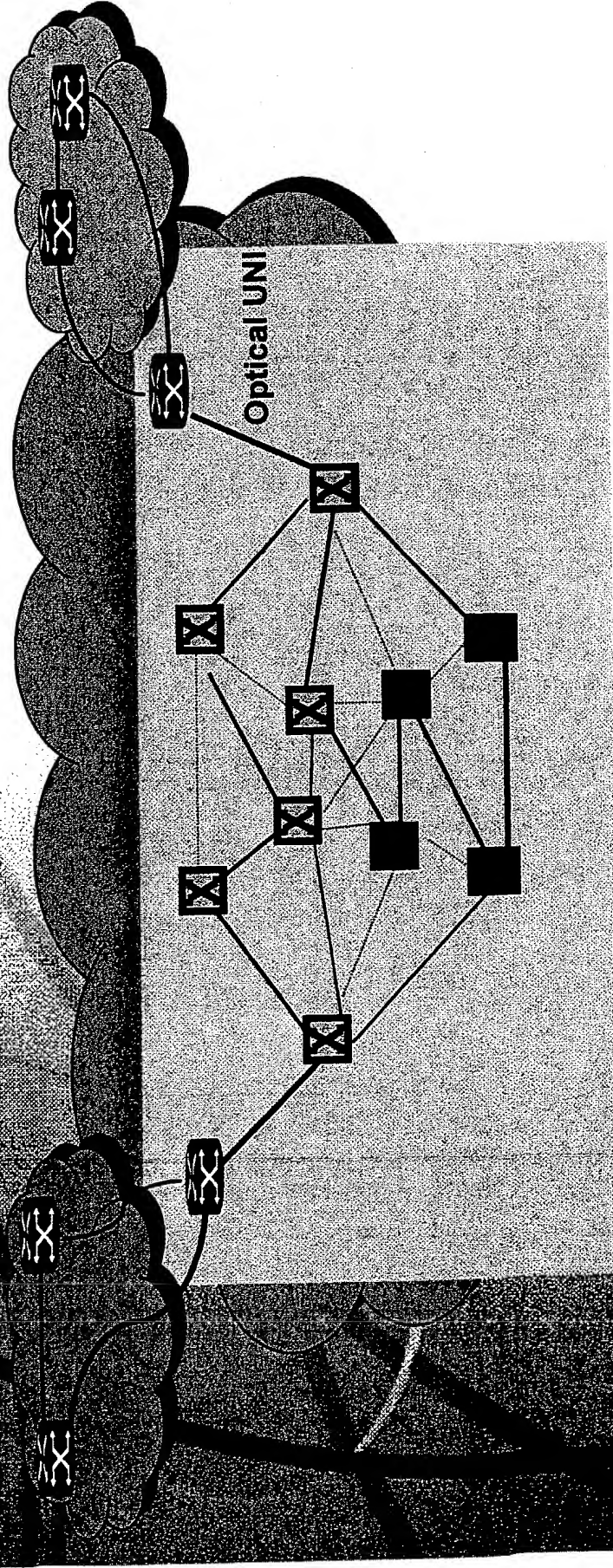
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# Peer-to-Peer Model



# Augmented Model



# *Why we need hybrid optical service model*

## ◆ Service flexibility

- Serve for trusted and UN-trusted user
- Unify service interworking control, does not require configuration
- UNI end-point address resolution
- Overlay service network established transparently to optical backbone
- Flexible service billing

## ◆ Service domain partitioning

- Support O-VPN service in simple yet effective manner
- Ease service/network management and CNM (Customer Network Management) implementation

## ◆ Traffic engineering

- Bandwidth utilization
- IP Layer protection



# Domain-constrained Optical route flooding

## **◆Optical User Group Identification (OUGI)**

- O-UNI related
- User Termination Point
- User Group ID (e.g, VPN ID)
- User Contract ID
- User Service Mode (i.e, overlay, peer-to-peer, augmented)

## **◆Optical Link Administrative Domain**

- Customized-Link related (link color)
- Broadcast (255.255.255.255)
- Block (0.0.0.0) -- default
- Specific User Group ID

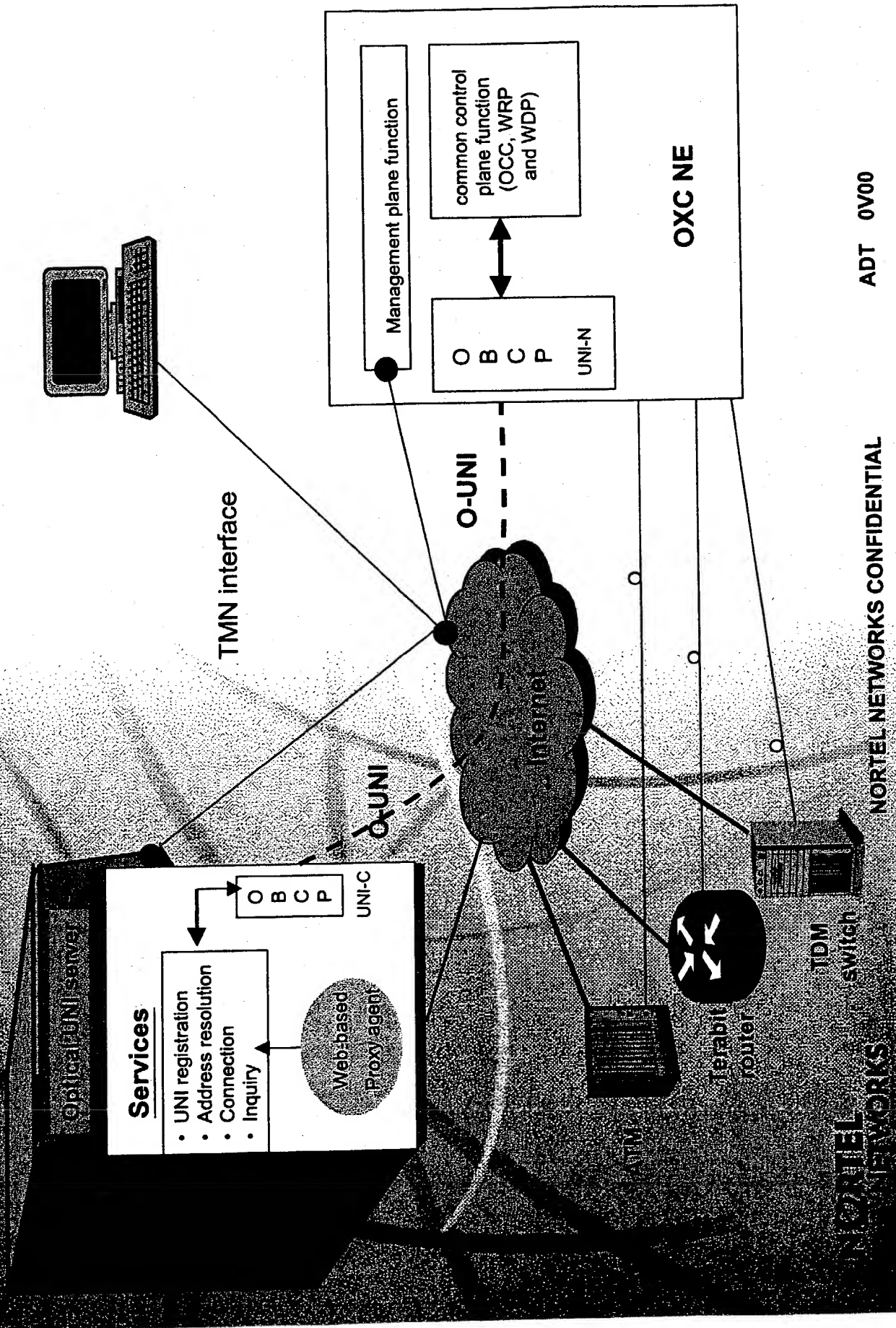
## **◆Optical Service LSA**

- Extension to Optical LSA (IETF proposal)
- Optical Interface Descriptor TLV including:
  - User service type (e.g, ATM, IP, etc), Control protocol (BGP, PNNI, etc), Framing protocol (e.g, GE, OC-x, Fiber channel, etc), OUGI, and link color

# Flooding Restriction for Service Mode

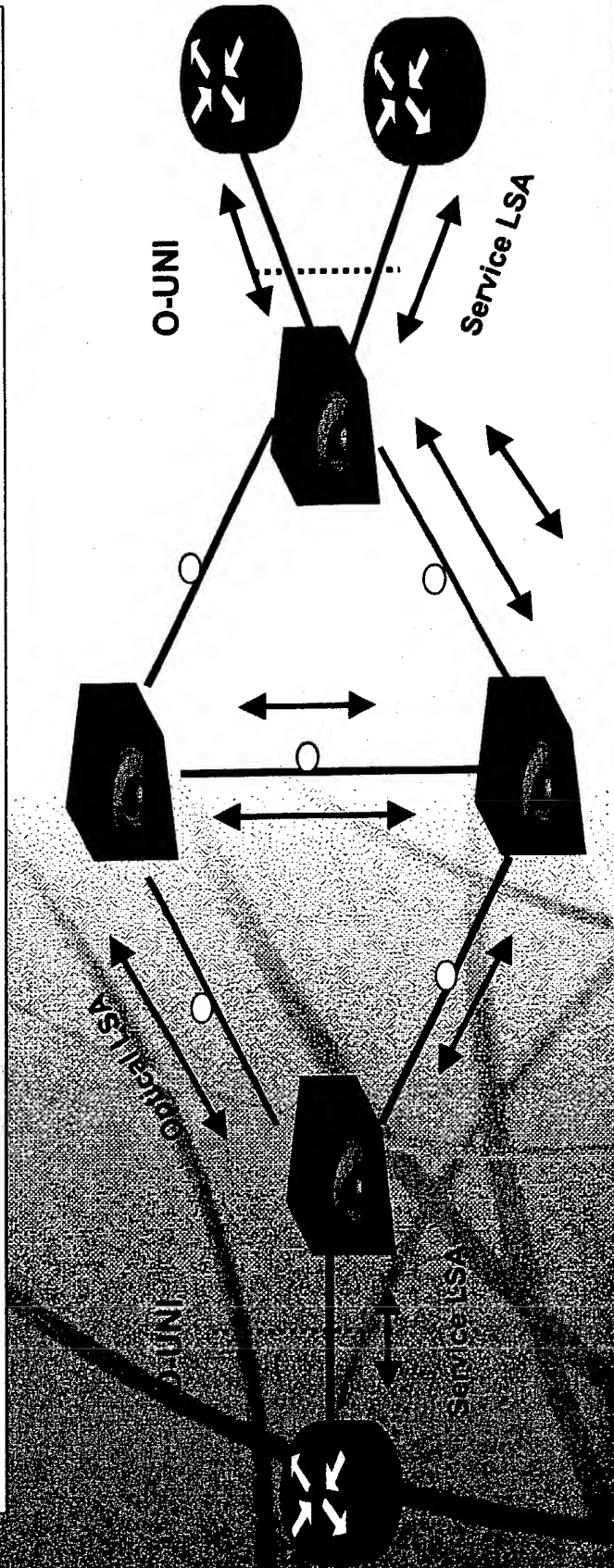
Service Mode	Service LSA	Optical LSA	Other LSA
None (0)	Block	Block	Block
Overlay Mode (1)	Flooding	Block	Block
Augmented Mode (2)	Flooding	Flooding	Block
Peer-to-peer Mode (3)	Flooding	Flooding	Flooding

# O-UNI client-server distributed architecture





# Optical LSA and Service LSA Propagation



## WRP& WDP

- O-UNI / NNI is configured for each link
- WRP floods Service LSA and Optical LSA
- Optical switches check flooding domain to decide broadcast or block the propagation
- WDP issues connection request with the check of the optical UNI interface type user group ID, and available bandwidth.
- The request is confirmed or rejected.

# Optical Network with user routing domain

conditioning

Private optical network

Public optical network

Optical Network

Restrictive flooding over NNI

- Broadcast link
- Green group link
- Yellow group link
- Red group link
- Yellow group ED
- Red group ED
- OXC/ONE
- ADT 0V00

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# Summary

- A hybrid optical service model is proposed
- Domain-constrained optical route flooding is proposed to support the hybrid service model
- Optical Interface Descriptor (OID) is defined to restrict the flooding domain
- Optical Service LSA is proposed to propagate OID
- Value-added features to IETF proposals
- Potential standard activity to IETF and OIF